

Wheelbarrow Races

Build a wheelbarrow to carry the most golf balls a distance of 10 feet.

Subjects and Skills

- ◆ Work, force, simple machines
- ◆ Circumference
- ◆ Measurement conversion
- ◆ The history of using simple machines to do work

Materials

- ◆ Index cards
- ◆ Sturdy paper
- ◆ Plastic spoons
- ◆ Large buttons
- ◆ Paper cups
- ◆ Popsicle sticks
- ◆ Golf balls

Vocabulary

- ◆ Wheelbarrow
- ◆ Mural
- ◆ Barrow
- ◆ Diameter
- ◆ Levers
- ◆ Wheel
- ◆ Axle

Purpose

Understanding the ways in which simple machines (levers and wheel-axle combinations) enable people to use less effort is a fundamental engineering concept. Students will extend their knowledge to the design of Class 2 simple machines and practice the work formula ($Work = Force \times Distance$).

Objectives

Students will gain a better understanding of:

- ◆ the history of the wheelbarrow;
- ◆ how levers work with axle-wheel combinations to ease exertion;
- ◆ converting units of measurement;
- ◆ finding circumference of a circle;
- ◆ the functionality of the design of the bucket, fulcrum, and wheel; and
- ◆ the $Work = Force \times Distance$ formula.

Activity Preparation

1. Run off activity sheets.
2. Gather materials and place them in two different areas of the classroom.
3. Bookmark websites to be used in class.
 - a. <http://vimeo.com/2236446>
 - b. <http://www.mikids.com/SMachinesWheels.htm>

Activity Procedure

1. Distribute activity sheets and have students read information.
2. Review the information from the first section of the sheet. Students will sketch wheelbarrows in the space provided and will answer Question 1.
3. Share a video (03:03) at Link a. of a wheelbarrow in action as it is used for carrying baby orangutans after they play in the forest.
4. Ask students to add more information to their responses to Question 1 as they think of ideas.
5. Continue with a discussion on levers and wheel-axle combinations. Ask students to identify examples of the wheel-axle combinations in our world (e.g., bicycles, games, toys, cars). Use Link b. as a resource.
6. Allow students to work on Questions 2 and 3.
7. Review answers to Questions 2 and 3: 6 cubic feet = 10,368 cubic inches; this area would hold 216 bricks (each brick measuring 6" x 4" x 2").
8. Discuss wheel options. Narrow tires are easy to maneuver in small spaces but can be prone to tipping. Wide tires carry heavy loads and suit soft surfaces like lawns, but can be difficult to wheel around narrow paths. Rubber tires are easy to use, soft on gardens, and more versatile.
9. Have students work on Question 6.
10. Review the answer to Question 6. $\text{Work} = \text{Force (effort)} \times \text{Distance (time)} = (75)(15)(216)(4) = 972,000 \text{ N}$.
11. Ask students to refer back to Question 1. What other ideas did they come up with? Discuss their responses.
12. Write: 16 oz = 1 lb. Ask how many ounces are in 1.5 pounds (24 oz). A golf ball weighs 1.62 ounces. Write this on the board and ask approximately what fraction of a pound this is (approximately 1/10).
13. Put students in groups of two or three, and assign group numbers.
14. Review the team challenge, answering any questions students may have.
15. After the team challenge has been completed, follow up with second set of questions on the activity sheet. To review Questions 1 and 2, circumference = 5.28 in, radius = .84 in., and area = 2.22 sq. in.
16. If you wish, assign one of the projects suggested in Extend the Learning With Wheelbarrows: Activities.

Name: _____ Date: _____

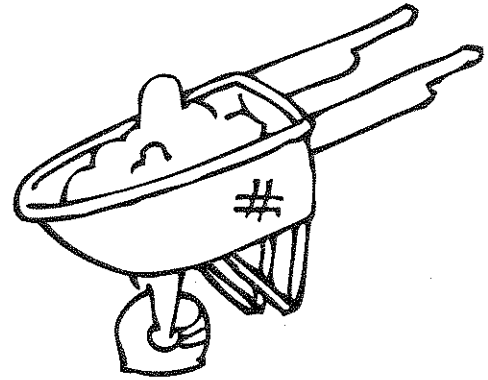
Wheelbarrow Races

GOAL

- Build a wheelbarrow to carry the most golf balls 10 feet or further.

MATERIALS

- Index cards
- Sturdy paper
- Plastic spoons
- Large buttons
- Paper cups
- Popsicle sticks
- Golf balls



TIME TO CREATE

- 20 minutes

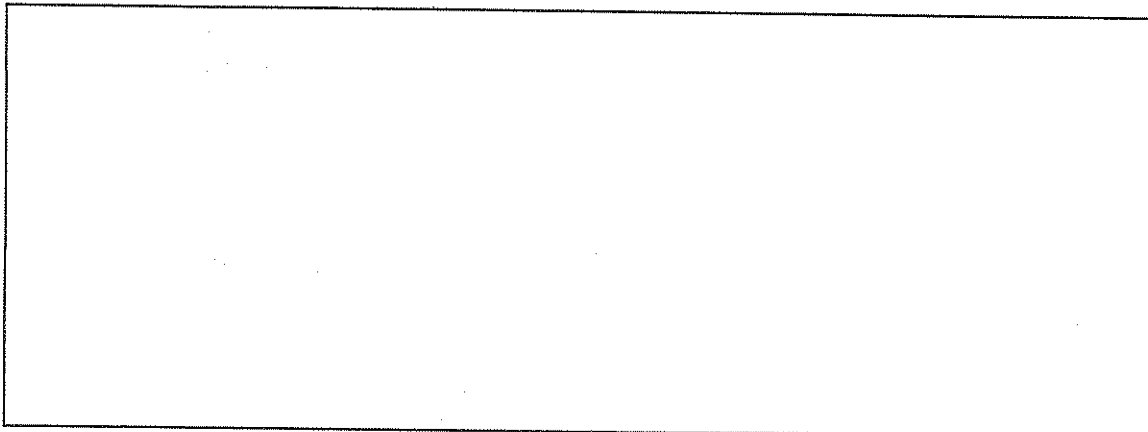
INDIVIDUAL ACTIVITY

Read the following, highlighting important information, and then answer the questions.

The wheelbarrow has been around since ancient times. One type of wheelbarrow may have been used in ancient Greece, around 400 B.C., although there is not enough evidence to say so definitively. We do, however, have evidence (from a mural) that wheelbarrows were used during the Han Dynasty (118 A.D.) to transport injured soldiers and supplies. Wheelbarrows originally had two wheels and needed to be moved and steered by two men.

Wheelbarrows did not have their name until the 13th century, when Europeans referred to boards used to transport loads as barrows. When the wheel was added, the barrow became known as a wheelbarrow. A wheelbarrow is a Class 2 machine that uses two simple machines: a lever and a wheel and axle. With a lever, a wheelbarrow helps to lift heavy loads. Levers consist of two effort points and a fulcrum. The wheelbarrow's effort points are the handles and the bucket. The handles are used to lift a load, and the bucket holds the load. The wheel is the fulcrum that allows the wheelbarrow to pivot.

Draw a sketch of a wheelbarrow. Make sure you label the important parts: a bucket to hold the load, a lever to lift the load, and a wheel to transport the load.



1. Wheelbarrows have not changed much in the past 2,000 years, but they still serve an important function in our lives. How do we use wheelbarrows today? _____

2. Wheelbarrows allow more goods to be moved in a single trip. If the average wheelbarrow can hold about 6 cubic feet of material, how many cubic inches would that be? _____

3. How many 6" x 4" x 2" bricks could a wheelbarrow hold? (This would be a heavy load, given that each brick weighs about 4 lb.) _____

4. The wheel enables the load to be moved easily and reduces the effort. Thinking about different sizes and types of wheels, how does the radius of the wheel affect the wheelbarrow?

5. Compare and contrast narrow tires with wide tires. Think about maneuverability, stability, and path surfaces.

6. The formula for the relationship between work, necessary force, and distance a load is moved is $Work = Force \text{ (effort)} \times Distance \text{ (time)}$. Imagine the amount of work you might do on an assignment. If you decrease the force (or effort), you would need to increase the distance (or amount of time) in order to complete the job. It's the same when you are doing physical work. Solve this problem: A 75-pound boy is lifting the bricks from Question 3 and taking them to the construction site 15 meters away. How many Newtons of work will that require?

TEAM CHALLENGE

Participants will work together in teams of two or three for 20 minutes to make a sturdy wheelbarrow that travels a distance of at least 10 feet while carrying a load of three or more golf balls. Make sure your team's wheelbarrow is sturdy enough to hold the load and is able to move easily.

When your teacher starts the time, your team will have exactly 20 minutes to gather your materials and build your wheelbarrow. Once the teacher signals that time is up, stop working immediately.

and bring your wheelbarrow to the challenge site. Any team that continues to work once time is up may be disqualified.

Start Time _____: _____ + 20 Minutes = _____: _____ End Time _____

From a specific starting point, each team will line up with wheelbarrows loaded with the weight. This is not a race. Each team must cross over the finish line with all of its golf balls still safely stored inside the wheelbarrow. If a golf ball escapes from the wheelbarrow, that team will mark that spot as its wheelbarrow's end point. The goal is to have your wheelbarrow carry the greatest weight to the finish line without touching down or spilling its contents.

After the team challenge, answer the following questions.

1. If the diameter of a golf ball is 1.68 inches, then what is the circumference (rounded to the nearest hundredth)? _____
2. What is the golf ball's radius? _____
What is its area? _____
3. Measure the distance that your team's wheelbarrow traveled. _____
4. How many golf balls was your wheelbarrow able to carry? _____
5. If a golf ball weighs 1.62 oz, how many oz did your wheelbarrow carry? _____
6. Approximately how many pounds is that, rounding to the nearest pound? _____
7. How many golf balls was the most successful wheelbarrow able to carry? _____
8. Expressed in ounces, how much weight was the most successful wheelbarrow able to carry?

9. What contributed to whether a wheelbarrow was successful? _____

10. What factors hurt some wheelbarrows' performance? _____

11. How does the design of the wheelbarrow help with transporting materials?

12. If you were going to make another wheelbarrow, how would you improve on your design?

EXTEND THE LEARNING WITH WHEELBARROWS: ACTIVITIES

1. **Singing about simple machines.** Visit <https://vimeo.com/38295614> and <https://vimeo.com/38295788> and then write your own song about simple machines. Visit <http://www.pbs.org/teachers/connect/resources/3999/preview/?contactID=163798497&gwkey=PFFBPYJTE8> for practice writing lyrics to music. You can write your song in any genre you choose (e.g., pop, rap, classical, country).
2. **Investigating simple machines.** Visit <http://teacher.scholastic.com/dirtrep/simple/invest.htm> to investigate the facts of simple machines. Complete the observation report and record your findings. Do your work on separate sheets of paper, and turn them in.
3. **Advertising the wheelbarrow.** Videotape (or perform live) a commercial about your wheelbarrow. Learn more about the function of wheelbarrow at <http://gomestic.com/gardening/the-function-of-a-wheelbarrow> and incorporate new information into your commercial to teach your classmates.
4. **Building a better planet with wheelbarrows.** What else can you do with a wheelbarrow? Check out the experimental solar-powered wheelbarrow at <http://createdynamo.net/faq> or <http://www.getlofi.com/?p=1184> made from reclaimed waste. DJ Dynamo has created a disco wheelbarrow to take his tunes on the road. Write a news report about this invention and the potential implications for future innovation.
5. **Funky wheelbarrow designs.** Want to try your hand at designing a funky wheelbarrow? Annie has. Check out her funky designs at <http://www.funkybarrows.com>. Now design your own funky wheelbarrow. Use whatever materials you want, and create a truly funky wheelbarrow. When you're finished, create an ad similar to Annie's ads to sell your wheelbarrow creation. You might even e-mail Annie to share your ideas and make suggestions!